Stress Effects on Kinetic Processes

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Stresses in materials are common during fabrication and processing. Sometimes stress is deliberately designed into materials to improve performance. However, stress affects atomic diffusion in a way that currently cannot be predicted, and diffusion can make an enormous difference to device performance. In this research program, researchers are measuring the effects of simple, uniform stress states on atomic diffusion, and combining it with theoretical analysis of the directionality of diffusion in order to permit the prediction of the effect of an arbitrary stress on diffusion in an arbitrary direction.

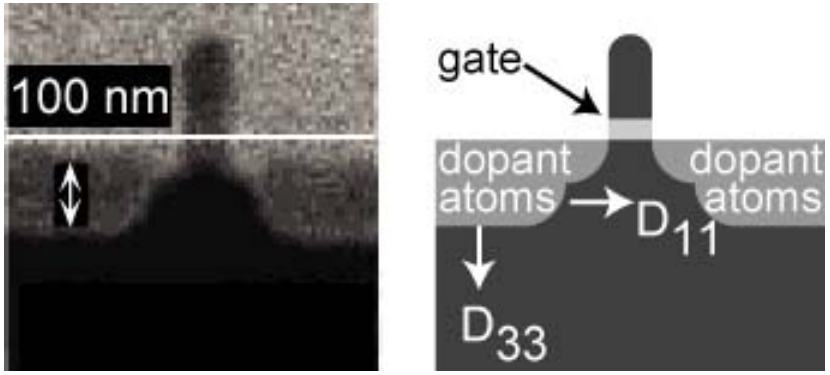

Image (left) and cartoon (right) of impurity (or "dopant") atom concentration in a 60-nanometer silicon transistor (adapted from O'Malley *et al.*, *Applied Physics Letters* **74**, 3672), shows how dopant atoms are distributed for new generation of faster, more compact electronic devices. Device properties are extraordinarily sensitive to horizontal diffusion (D_{11}) of dopant atoms during processing. In the absence of stress the rate of horizontal diffusion should be just as fast as vertical diffusion (D_{33}), but in these devices D_{11} appears to be greater than D_{33}. It is believed that stress, which concentrates near the bottom of the gate due to the way it is fabricated, plays a significant role in altering D_{11}.

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Outreach:
The Principal Investigator is shown demonstrating rapid quenching techniques, and the resulting modifications to the properties of materials such as flowers, cream, sugar, and fruit, for kindergarten students.